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THE RELATION OF COLOR TO FLAVOR IN FRUITS
AND VEGETABLES.

BY EMMETT S. GOFF.

DURING the summer of 1882 I was struck by the coincidence that in several of our fruits and vegetables a white or light colored flesh is accompanied by a milder and more delicate flavor than exists in other varieties of the same fruit or vegetables having a dark colored flesh. Thus the white varieties of onion are milder in flavor than the red ones; the white currants possess less acidity than the red ones, and these in turn have less pungency than the black varieties; the white and yellow tomatoes are sweeter than the red ones; the white and yellow raspberries are more delicate in flavor than the red ones, and these in turn have a less strongly marked flavor than the black varieties. The familiar custom of blanching celery, endive, sea-kale, the cos lettuce and other plants to give them a more delicate flavor, was called to mind, and the fact that the inner leaves of the cabbage head which are white and decidedly more delicate in flavor than the outer green leaves; also that potato tubers "sun burned" through exposure to the light have a very strong and bitter taste. These and other instances came to mind, until I was led to ask whether there may not be a law of relation between the color and flavor in fruits and vegetables.

Every fruit and vegetable has a standard of quality peculiar to itself. This is based upon the natural qualities that make the fruit or vegetable desirable to man. Thus in most fruits quality is based upon delicacy and richness of flavor, with a certain degree of tenderness in the flesh. In many salads it is based upon crispness, tenderness and mildness in flavor; in a few, as the cress, it is based upon pungency. In some vegetables, as the potato and squash, quality depends upon the dryness and farinaceous properties of the flesh, combined with a delicate, characteristic flavor.

In the amelioration of fruits and vegetables, it is the constant aim of the horticulturist to intensify, so far as possible, the desirable qualities and to eliminate the undesirable ones. It is evident, therefore, that if it can be shown that the color of the flesh has a direct relation to its flavor and tenderness, we have a valuable index in the work of selection. If by whitening the flesh

of a fruit, through selection, we can eliminate acid and solidity, or if by darkening the flesh of another fruit, already too tender and insipid, in the same way, we can heighten its characteristic flavor, and increase its firmness, we have gained a new faculty in the work of making the products of nature subservient to our wants.

The hypothesis was therefore assumed, that in a white flesh, in fruits and vegetables, we escape solidity, and a strongly marked characteristic flavor, with a gain, or at least without a loss, of sweetness. This hypothesis was applied to the fruits and vegetables of which I have been able to find complete descriptions. The results of my researches will be given further on.

If the law exists which my hypothesis assumes, it is evident that the processes of selection have operated more or less to obliterate the marks by which it may be traced. Seedlings or sports yielding fruits having a very harsh or acid flavor have been rejected, whatever the color of their flesh. On the contrary, deep colored samples possessing a pleasant flavor, though exceptions to the law, have been preserved. Thus in many cases we are compelled to trace out the law with but half of the evidence. For example, the blood clingstone peach, which is said by Mr. Downing to have flesh "very red, like that of the beet," is pronounced "not fit for eating." Red fleshed peaches are very rarely mentioned in our fruit books. Possibly the reason why so few red fleshed varieties have been preserved is, that their flavor and firmness were such as to make them undesirable.

We may fairly assume that palatability has been a leading principle in selection, and that the color of flesh has had influence only in a few cases where appearance is of some importance. In the currant, the principal use of which is in the manufacture of jelly, the red color is preferable, because, as every one knows, the rich crimson color of jelly made from red currants is more attractive than the pale color of that made from the white currant, though it is equally well known the latter has decidedly the milder flavor. So in the beet and carrot, the rich colors of the deep red varieties of the one, and orange sorts of the other, are more desirable for the table than the paleness of the milder white varieties; and further, as there is no acid in these roots to overcome in their amelioration, their agreeable characteristic flavors are more developed in the deeper fleshed varieties. In the apple,

on the other hand, in which, as I think we may fairly assume, the factor which it was most necessary to eliminate in its amelioration is a harsh acid and an over-firmness, the majority of the varieties are white fleshed. So in the pear, we may assume that toughness and astringency were the qualities to be overcome, hence in this fruit we have mainly white fleshed varieties. In the plum and peach, however, in which the acid element is not very prominent, and which possess very little solidity by nature, we obtain higher characteristic flavors in the varieties having yellow or orange flesh.

Since adopting my hypothesis I have noted down such statements as I have chanced to find in horticultural reading, as bearing directly upon this subject. The extracts here recorded from several different authors seem to recognize the law as applying to special cases, but I have nowhere found evidence that any one has conceived it to be of general application.

In speaking of the leaf, or chard, beet, M. Henri Vilmorin says, in "*Les Plantes Potagères*," p. 422: "It seems that in all the leaf beets the white color of the leaves accompanies a sweet taste, while a deep green color is indicative of a strong and bitter taste."

In speaking of the turnip the same author recognizes a popular prejudice that white fleshed turnips are milder than those having yellow flesh, and which he is disposed to contradict. With all deference to this great horticulturist, I will say that the result of my own investigations, the detail of which I shall give further on, is confirmatory to the prejudice that he declares poorly founded. He says in the work just cited, p. 362: "It is certainly wrong that in Paris the yellow fleshed turnips should be less esteemed than others. It is here considered that the yellow color is accompanied with a strong and bitter taste, which is far from correct, for we find among the yellow turnips varieties possessing very tender flesh and of very delicate flavor, as well as in the white varieties." It will be observed that this statement does not contradict the existence of a greater proportionate number of mild flavored turnips among those that have white flesh.

Mr. Fearing Burr, Jr., says of red cabbages, in "*Garden Vegetables*," p. 142: "When cooked they are considered less mild and tender than the common varieties."

Regarding the comparative tenderness and delicacy of blanched

and green asparagus stems, Mr. Robinson, in his "Parks and Gardens of Paris," p. 472, quotes the opinion of a French epicure as follows: "In certain localities they do not yet value the distinction between blanched and green asparagus, and occasionally prefer the latter. That is an error very prejudicial to the consumer's interests. Properly blanched asparagus is infinitely more tender and delicate. All asparagus cut when it is green is not fit to be eaten in the ordinary way, but may be used, cut up small, as an accompaniment to other dishes. To serve up green asparagus is to dishonor the table. In the markets of Paris the green asparagus is worth one franc a bunch, when the blanched is worth three francs."

It has often been a question to my mind why the white beet is almost exclusively used in the manufacture of sugar. I had supposed that the difficulty of eliminating the color from the juice of the red beet to be the probable reason why the latter is not used for this purpose. I have been able to find very little bearing upon this subject, but that little indicates that the principal reason is that the white beet contains a larger percentage of sugar. Thus I find in Morton's "Cyclopædia of Agriculture," Vol. II, p. 925: "Formerly the field beet, with rose colored skin, and presenting, on being cut, alternate layers or zones of a white and a red color, was much more extensively grown in Germany and France for the purpose of sugar making than it is at present. Preference is now given to the White Silesian beet, introduced into France by Mathieu de Dombasle. The latter gives a larger percentage of sugar and contains less water, saline matters and nitrogenous substances than the former." According to M. Vil-morin, all the beets now used in France for the manufacture of sugar have been derived from the White Silesian variety.

In this connection I quote a partial analysis of three varieties of beet from the Transactions of the New York State Agricultural Society, 1852, p. 330. It notes the per cent of coloring matter and of the sugar and extract in each:

<i>Variety.</i>	<i>Per cent of Color- ing Matter.</i>	<i>Per cent of Sugar and Extract.</i>
Turnip beet .....	.038	43.039
Long blood .....	.0158	55.327
White sugar.....		60.023

We may infer from this that the per cent of sugar in these

samples of beet increased as the per cent of coloring matter decreased.

In speaking of the leek, Mr. Wm. N. White says, in "Gardening for the South," p. 241: "The whole plant is much used in soups and stews, but the most delicate part is the blanched stems."

Mr. Charles Downing, in his admirable "Fruits and Fruit Trees of America," p. 629, says of the yellow fleshed peaches as grown under European climates, that they "require our hot summers to bring out their flavor. In a cold climate the acid is always prevalent." From the connection it is evident, as the reader may observe, that this is true especially of peaches having yellow, rather than "pale" flesh.

In speaking of the edible podded or sugar pea, the author of "Les Plantes Potagères" says (p. 423): "The seed of purple-flowered peas is always more or less colored or spotted with brown; it assumes a somewhat disagreeable grayish color when cooked, and has besides a rather strong and bitter taste."

In speaking of carrots the same author says, in "Le Bon Jardinier," 1882, Part 1, p. 437: "The red carrots have in general a more pungent taste than the yellow and white;" and again, on the same page, "the white carrots are esteemed for their sweetness."

Mr. Burr says of the Long White carrot: "Flesh white, and generally considered sweeter than that of the colored varieties."

In speaking of the mushroom, the author of "Les Plantes Potagères" says, on p. 82: "It seems to us, after several comparative trials, that the white variety is preferable to the others as a vegetable. The light-colored (blonde) variety appears to us less tender and perfumed [than the white], the gray has, on the contrary, a stronger taste."

Mr. Burr, in "Field and Garden Vegetables of America," p. 284, quotes the following in relation to the sea-kale: "These shoots form the edible portion, and being blanched under ground they are tender and white, and from six to eight inches long. The shoots should be cut as soon as they reach the surface, because if the shoot comes through, the top gets purple, and the plants become strong flavored."

The same author pronounces the blood red onion, in which not only the outer coats but the inner ones, except those most central, are stained red, "one of the strongest flavored of all varieties."

The large red is said to have "purplish white" flesh, and to be "stronger flavored than that of the yellow or earlier red varieties."

But of more value than all the testimony of impressions and quotations, is the result of a careful investigation of existing varieties. Do the varieties of fruits and vegetables, as described by unprejudiced horticulturists, when put to the test of figures, show clearly that mildness and sweetness accompany light colored flesh to a greater extent than dark colored? This is the test question. In the tables that follow, the testimony on the fruits is gathered mainly from Downing's "Fruits and Fruit Trees of America," and that on the vegetables from Burr's "Field and Garden Vegetables of America."

I have gathered in the table only such terms as express a definite quality, and which apply to my present purpose. Many terms are used, such as "delicious," "pleasant," "agreeable," "good," etc., which convey nothing specific in regard to flavor. Many shades of color are also delineated which are intermediate between the extremes, such as "greenish white," "yellowish white," "greenish yellow," etc. These I have not used, as the number of varieties to which they are applied is, in most cases, small, and they do not apply directly to the present purpose. Sometimes, for the purpose of simplifying the table and increasing the number of varieties, I have united two or more terms, which mean very nearly the same thing, into one. Thus the "deep yellow" as applied to the peach in the table, includes those described as "orange," "deep orange," "orange yellow," "rich yellow," etc.

In the table of vegetables the numbers are too small to make the testimony of much value, though so far as it goes the evidence is decidedly confirmatory to the hypothesis:

	Color of Flesh.	Number of Varieties.									
		Number of Varieties.	Per cent "Sweet."	Per cent "Mild."	Per cent "Delicate."	Per cent "Tender."	Per cent "Melting."	Per cent "Juicy."	Per cent "Crisp."	Per cent "Firm."	Per cent "Rich."
Apple	White	156	22	17	4	73	2	60	13	7	24
	Whitish	40	25	25	5	77	2	65	20	7½	20
	Yellowish	92	20	22	0	55	4	59	30	14	44
	Yellow	74	18	9	1	42	0	45	27	15	60
Pear	White	198	57	..	6	45	63	69	..	..	23
	Whitish	51	49	..	0	0	82	78	..	..	35
	Yellowish	16	38	..	0	0	81	63	..	..	44
	Yellow	3	33	..	0	0	33	100	..	..	33
Peach	White	21	33	..	5	..	71	81	..	5	43
	Yellowish	22	60	..	0	..	14	45	..	14	45
	Yellow	73	52	..	0	..	18	52	..	7	33
	Deep yellow	26	23	..	0	..	15	42	..	8	27

	Color of Flesh.	Number of Varieties.									
		Number of Varieties.	Per cent "sweet," "sugary."	Per cent "mild."	Per cent "delicate."	Per cent "well flavored."	Per cent "farinaceous," "mealy."	Per cent "dry."	Per cent "tender."	Per cent "fine grained."	Per cent "coarse."
Potato	White	12	..	8	..	58	58	75	..	..	..
	Yellow	7	..	0	..	0	14	28	..	14	14
Turnip	White	13	100	16	..	..	..	50	53	..	..
	Yellow	8	75	0	..	..	..	46	25	..	..
Ruta бага	White	4	100	50	25	..	..	..	25	..	..
	Yellow	6	50	0	0	..	..	..	17	..	..

It will be observed that in every case where the terms "sweet," "mild," "delicate," "tender" and "melting" are used, the per-

¹ One was called "very well flavored."

² Of these one-third or twenty-five per cent were called "very dry."

³ Two of these, or fifty per cent, were called "very sweet."

centage is highest in the white fleshed varieties. It appears also that the per cent of acidity is greater in varieties having dark colored flesh. In the pear the percentage called "sub-acid" is decidedly greatest in the white fleshed varieties. This may at first seem contradictory to my hypothesis. It should not be forgotten, however, that in the apple and pear a mild acidity greatly improves the flavor, and hence this apparent exception is possibly the result of selection.

In the plum no varieties are said to have white flesh. I find, however, that in five varieties in which the flesh is called "amber color," and three called "pale green," none are called acid; while in fifty-nine varieties called "yellow," five have some acid, in thirty-three called "greenish yellow," three are called acid, in twenty called "greenish," five are called acid, and in nine called "greenish yellow," three are called acid.

In the other fruits and vegetables I have not found sufficiently accurate descriptions to permit me to judge whether the hypothesis holds or not.

If further investigation should discover sufficient evidence in this direction to establish a law, this law will have an important practical application in the amelioration of fruits and vegetables.

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GROWTH, ITS CONDITIONS AND VARIATIONS.

BY CHARLES MORRIS.

(Continued from page 1101, November number.)

FAR back in the history of life we reach a period in which crustaceans and mollusks seem to have been the lords of the earth. During the greater part of the Palæozoic age the ocean invertebrates were dominant, they grew to great size, developed rapidly in functional ability, and swept the seas of their stores of food. We know little of the struggle which then took place between the various invertebrate sub-kingdoms, or of their probably successive rise to supremacy. Nor can we trace the struggle between the members of each sub-kingdom. So far as evidence goes the cephalopods would seem to have been contemporaneous in origin with humbler representatives of their race and of other races. But this is doubtless an illusion produced by an undue crowding together of the geological tablets.

This invertebrate era was succeeded by the earliest stage of